RELATIONSHIP OF *SPHAERIUM SOLIDULUM* PRIME TO ORGANIC POLLUTION

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This investigation was prompted by varied statements in the literature concerning the relationship of the Sphaeriidae of the genera *Sphaerium*, *Musculium*, and *Pisidium* as they may or may not be related to organic pollution, by a desire of the writers to suggest quantitative methods for the collection of bottom organisms in a small creek and for a valid expression of numbers of benthonic organisms.

The field work was carried out on Lytle Creek (with a c. f. s. of approximately 0.55 to 7.0), in the vicinity of Wilmington, Ohio. The source of organic pollution in Lytle Creek is domestic sewage from Wilmington with a population (1950 census of population, preliminary counts) of 7,412. Wilmington is sewered and has primary sewage treatment facilities. This treatment is not enough, however, to prevent septicity from setting in in the stream during periods of low flow. Stream surveys made in August, September, and October of 1950 showed that septicity extended from the sewage treatment plant outfall to approximately one mile downstream.

Data included here were collected by the writers sporadically from March 1950 through June 1951 in association with a field reseach problem by the Biology Section of the Environmental Health Center. The chemical and bacteriological data are presented to show generally the possible characteristics of a stream at certain stations; such data were gathered during August 15–18, 1950.

Lytle Creek at the time these studies were made was relatively free from wastes other than treated sanitary sewage.

The Sphaeriid that the writers deal with in this paper is *Sphaerium solidulum* Prime. Collections of this finger-nail clam made during 1950 and 1951 indicate that its distribution in Lytle Creek in relation to organic pollution is static and does not vary as chemical and bacteriological data quite naturally do.

CHEMICAL AND BACTERIOLOGICAL DATA

Complete chemical data are not available for each clam collecting station. They are presented here to show the general chemical and bacteriological characteristics of certain stations at static times; for example, chemical data are presented for control station 8. 7, sewage plant outfall, and point of mixing of effluent and stream.[2] The chemical data in each instance represents the average of 12 composite samples taken every two hours for three 24 hour periods between August 15-18, 1950.

Control station 8.7 is unpolluted except for drainage from farm lands. Chemical and bacteriological data are: pH, 7.9; M. O. alkalinity, 219 p.p.m.; chloride, 0.12 p.p.m.; total nitrogen, 6.59 p.p.m.; NH_3–N, 0.2 p.p.m.; NO_2–N, 0.016 p.p.m.; NO_3–N, 0.16 p.p.m.; total PO_4, 0.55 p.p.m.; soluble PO_4, 0.15 p.p.m.; 5 day B. O. D., 1.71 p.p.m.

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[2]Station figures cited here, i.e., 8.7, represent miles and tenths of miles above the mouth of Lytle Creek.

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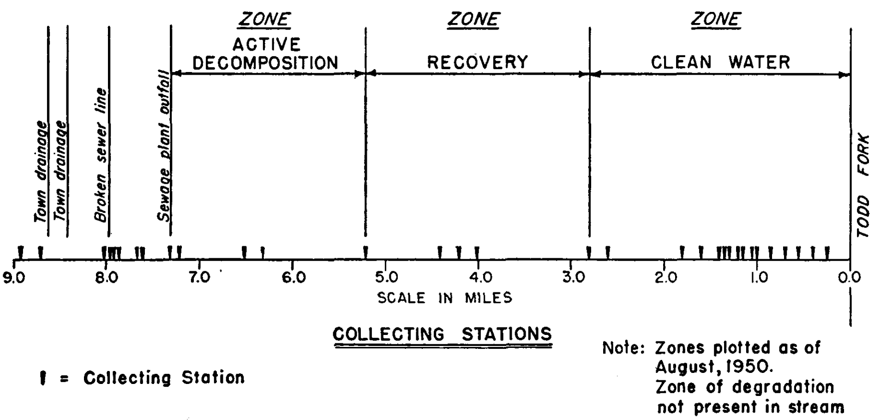
The sewage treatment plant effluent showed the following data: pH, 7.0; M. O. alkalinity, 253 p.p.m.; chloride, 39.0 p.p.m.; total nitrogen, 35.0 p.p.m.; NH_3–N, 23.5 p.p.m.; NO_2–N, < 0.002 p.p.m.; NO_3–N, 0.14 p.p.m.; total PO_4, 15.0 p.p.m.; soluble PO_4, 10 p.p.m.; 5-day B. O. D., 159 p.p.m.

The point of mixing of the sewage treatment plant effluent and stream showed: pH, 7.1; M.O. alkalinity, 235 p.p.m.; chloride, 41 p.p.m.; total nitrogen, 28.7 p.p.m.; NH_3–N, 18.5 p.p.m.; NO_2–N, < 0.002 p.p.m.; NO_3–N, 0.14 p.p.m.; total PO_4, 12.0 p.p.m.; soluble PO_4, 8.0 p.p.m.; 5 day B.O.D., 124 p.p.m.

Data for bacteria of the coliform group for two stations showed a M. P. N. per 100 ml. of < 100 at station 8.7 and a M. P. N. per 100 ml. of 30 million at the point of mixing of the effluent and the stream.

Stream flow at a gaging station below the sewage treatment plant effluent indicated that during the period that the above chemical and bacteriological data were gathered the flow was approximately 0.55 c f s. Ninety-four percent of the flow in Lytle Creek below the sewage treatment plant at the time data were gathered consisted of the sewage plant effluent.

POLLUTION ZONES—LYTLE CREEK
REFERENCED TO
SPHAERIUM COLLECTING STATIONS



DISCUSSION OF LITERATURE

As indicated by selected references relative to pollution as cited below, data on the Shaeriidae are quite qualitative, sometimes having been compiled without exact cognizance of the pollutant or of the specific relationship of these clams to the pollutant. Statements that indicate that the Sphaeriidae as a group are tolerant to water fouled by domestic sewage do not always appear to be valid when related to the findings of the writers. Instead it appears that the Sphaeriidae should be identified to species as certain ones may or may not relate to pollution from domestic sewage.

Suter and Moore (1922) state in reference to *Pisidium abditum* Hald. for New York State, ". . . a mollusk which attaches itself to plants carrying sludge accumulations. Thrives in waters polluted by domestic sewage." Richardson (1928) in his work on the Middle Illinois River states in reference to *Musculium* *transversum* (Say), "No index value; equally common in some situations on clean bottom, and believed to be a case of recent adaptation." This writer in the same paper in tabulation of the tolerance of various organisms to "pollution" lists *Pisidium compressum* Prime, *Musculium transversum* (Say), and *M. truncatum* (Linsley) in his "Subpollutional, unusually tolerant; common to abundant at some stations in the pollutional, zone; but with original natural preference for the subpollutional or cleaner water zones." Richardson (1928) lists *Pisidium pauperculum* var. *crystalense* Sterki, *P. complanatum* Sterki, *S. striatinum* var *lilycashense* F. C. Baker and *S. stamineum* (Conrad) in his "Subpollutional, less tolerant, more common species; normally preferring clean water; but able stand subpollutional conditions even where current is slight."

Morgan (1930) makes the following general comment relating to the type of bottom and type of water with which the Sphaeriidae may be associated. "They are widely distributed, almost sure to be found in any kind of fresh water. They live on bottoms of sand and mud or clay and often creep up over plant stems." Carpenter (1928) writes in relating *Sphaerium* to organic pollution, "Passing away from the source of pollution, recovery sets in, owing to removal of organic matter by decomposition and digestion, and absorption of oxygen from the atmoshere. In this phase detritus feeders are dominant: particularly high numbers are attained by Protozoa in great variety, especially Ciliates and Flagellates, Oligochaets, and Nematodes; to these are soon added small Lamellibranchs (especially *Sphaerium*), Limnaea, and many Diptera surface-breathing larvae (as *Ptychoptera*, *Psychoda*, *Stratiomys*, [*Stratiomyia*] *Culicidae*). . . . . ."

Baker (1922), working in Illinois, presents the following data on the relation of the Sphaeriidae to pollution: "The distribution of the *Sphaeriidae*. . . is interesting and significant in connection with the sewage pollution of the stream . . . no *Sphaeriidae* were found. . . between the Urbana ditch and . . . 14 miles below Urbana. These mussels are characteristic mud dwellers, and their absence from the intervening territory in the stream is striking evidence of the unfavorable conditions on the bottom."

Purdy (1930) in discussing the Sphaeriidae and pollution in his bulletin on the Illinois River states, "These small mussels are often very numerous in water which is moderately polluted; thus they are often to be found with Tubificidae. However, they cannot stand the extreme conditions that the worms can; hence will die out when oxygen becomes largely depleted. Apparently their large numbers in places where water is polluted is a question of their abundant food supply of microscopic organisms normally found there." Kehr, Purdy, et al. (1941) state in their bulletin on the Scioto River where reference is made to Purdy's (1930) paper, "Sediments from the upper sewage-polluted sections of the river had a strong, unpleasant odor. Organisms in these sediments consist chiefly of tubificid worms, which were very numerous averaging over 2,000 per liter of mud. Certain sewage-tolerant urganisms (*Sphaeriidae* and larvae of *Chironomids*) were moderately abundant. Such forms as are normally found in the odorless sediments of cleaner streams populated by fish were practically absent." Ellis (1937) writes the following on the *Sphaeriidae* in relation to organic pollution, "Studies of the bottom faunae of polluted streams, particularly those carrying quantities of organic pollution, have shown that many of the bottom species of unpolluted streams are sensitive to pollution conditions, so that as pollution progresses the normal fauna changes giving way to certain more tolerant species of tubificid worms, chironomid midges, spaeriid mollusks, and leeches." It is not the point of this paper to discuss extensively animal relationships in Lytle Creek, however, the writers but rarely found Tubificid worms associated with *Sphaerium solidulum* Prime. Gaufin and Tarzwell (1952) in their paper on Lytle Creek, Wilmington, Ohio, observed that *Sphaerium solidulum* Prime was not associated with water polluted by domestic sewage.

METHODS OF SAMPLING AND EXPRESSION OF ABUNDANCE

Sampling was carried out entirely by using an Ekman dredge 6 x 6 inches square. The dredge was adapted for shallow water sampling (by Dr. C. M. Tarzwell. Chief, Biology Section, Environmental Health Center) by riveting an iron pipe over the trigger mechanism, thus a messenger could be dropped through the pipe-handle to trip the trigger and close the dredge. The handle, thus riveted, functions as a stabilizer ensuring one of an exact position over a selected bottom area.

Through use of the messenger the same force is applied always to the grab of each sample, given a similar bottom stratigraphy. It was found by the writers that on the bottom preferred by *Sphaerium* the Ekman grab collected a fairly uniform one and one-half inches of sediment.

To determine a bottom stratigraphy where one could be assured of finding clams if they were at all present twenty exploratory Ekman hauls were made. A coarse sandy bottom is a typical substrate in Lytle Creek for *Sphaerium solidulum;* they are not found in fine silt deposits nor on shaley riffle areas where sand is lacking. They are not associated with sludge beds.

Here abundance of clams is expressed as the number of clams taken per five Ekman hauls that were taken as a representative sample at each station. The expression of the number of clams per acre or even per square foot of bottom based on single Ekman hauls at fixed stations would make numbers purely qualitative in a stream the size of Lytle Creek and with its varied bottom stratigraphy. This, therefore, was not done. In stream surveys, the writers feel strongly that numbers of individuals should be expressed in terms of collecting device employed, *i.e.*, Ekman, Petersen, Surber, thus number-of-individual figures become significant in relation to a fixed dimension that is a standard in the operators hands. Varied personal elements were removed from the actual collecting of samples in that the writers worked closely together on each Ekman haul, thus excluding variation that well could have taken place if hauls had been made by four collectors, each working alone.

DISTRIBUTION OF CLAMS

To determine the distribution of clams along some 9.0 miles of Lytle Creek, 180 Ekman hauls were made (table 1). These showed that clams reached their maximum abundance, eighty-five in 5 Ekman hauls, at station 8.7, the control station removed from pollution by domestic sewage. At station 8.9, an upstream check point used to determine the leveling off of clam abundance, 82 individuals were taken in 5 Ekman hauls, thus it was established that a near plateau existed between the "clean" water station 8.7 and check point 8.9 in clam populations, 85 *vs.* 82. Clam populations steadily dropped to station 8.0 where 37 were taken in in 5 Ekman hauls. Between stations 8.7 and 8.0 there existed 2 points where town drainage entered into Lytle Creek. Chemical and bacteriological data are not available at these points; however, it was observed by the writers that oily wastes were often present entering the stream from these drainage points, perhaps in sufficient quantities to affect clam abundance adversely in reducing food organisms.

At station 8.0 a broken sewer pipe allowed a trickle of sewage to enter the stream. This had no adverse effect on clam populations; to the contrary the clam populations increased just below the broken sewer pipe from 37 in 5 Ekman hauls at station 8.0 to 62 in 5 Ekman hauls 50 yards downstream, possibly reflecting the effect of non-injurious fertilization and indicating that the oily wastes that were entering Lytle Creek upstream from station 8.0 were not affecting the clam populations here. At station 7.9 populations dropped to 43 in 5 Ekman hauls, then increased slighty to 47 in 5 hauls at station 7.7, decreasing to 40 in 5 hauls at station 7.6, to fall sharply to 0 in 5 hauls at station 7.3, the sewage treatment plant outfall.

Associates of *Sphaerium solidulum* in the above stretch of stream were limited to a few forms which display special adaptations to enable them to live in or on the sandy bottom inhabited by this mollusk. These were nymphs of the mayfly, *Caenis;* dragonfly, *Libellula;* and larvae of the alderfly, *Sialis.* However, these forms, unlike *Sphaerium,* were also present in the clean water zone downstream from the zone of recovery.

From station 7.3 to station 0, where Lytle Creek joins Todds Fork, no clams were found. From station 7.3 to station 0, five Ekman hauls, all showing 0 results, were made at each of the following intermediate stations: 7.2, 6.5, 6.3, 5.2, 4.4, 4.2, 4, 2.8, 2.4, 2.0, 1.8. 1.6, 1.55, 1.50, 1.40, 1.3, 1.0, 0.85, 0.7, 0.55, 0.4, 0.25, and zero.

The disappearance of clams at 7.3 can be explained by low D. O. conditions setting in at this station where on occasion septicity immediately develops and holds through station 6.5. From station 6.5 through station 5.2, about the beginning of the zone of recovery, there is no especially obvious reason why clams should not re-appear except for the substratum being heavily coated with zoogleal organisms which could conceivably cut off their food and possibly even the oxygen supply, since zoogleal organisms would rest over the clams buried in the substrate. From station 5.2 through station 0 there are extensive areas of bottom that could be considered typical for clam abundance, however, claims remain absent.

An explanation for the absence of clams from station 5.2 to 0 is difficult. Any explanation offered can be only highly speculative. The writers first considered that the clam might be a headwaters species. To check this hypothesis, sampling was done on another creek, Cowan Creek, in the general vicinity of Wilmington, Ohio. Cowan Creek is bedded over similar geological strata and has typical clam bottom situations similar to Lytle Creek. Collections of clams on Cowan Creek dispelled the thought that we were dealing with a headwaters clam for they extended well downstream through the relative geologically mature stream bed.

It is conceivable that the flush-outs of Lytle Creek which occur below the sewage treatment plant, carry enough fine sediment from sludge areas in the stream below the outfall to prevent a clam population from becoming established in its lower reaches. The smothering effects of such sediment as it settles out could directly destroy clams. Some evidence is available for this hypothesis from whitened, dead clam shells that were taken in place in the basically sandy stream bottom at station 5.2.

It is further conceivable that with the flushing out of Lytle Creek along its course from month to month, that clams, washed down from upstream areas, could not successfully seed the mature stream bed and produce a growing thriving population. Thus as clams are washed downstream, from immature stream bed areas, many are lost on sand bars where they settle as the water subsides. Dead shells in such areas attest to this hypothesis.

CONCLUSIONS

The writers do feel that this general study does present the following pertinent data.

1. *Sphaerium solidulum* may respond to a slight fertilization effect from domestic sewage by increased productivity.
2. *Sphaerium solidulum* cannot live under conditions of septicity.
3. Silting effects populations of *Sphaerium* in the area studied, clams not being found on silt bottom in downstream areas below sludge deposits.
4. *Sphaerium* is not found where gelatinous zoogleal organisms cover typical *Sphaerium* bottom areas.
5. *Sphaerium solidulum* is not a headwaters species locally.
6. Numerical results of Ekman dredge samples in order to establish a quantitative expression which can be set as a standard, should be recorded in number per dredge haul, or in total numbers per total dredge hauls. An equal number

of Ekman hauls should be taken at each established collecting station.

7. Preparatory to conducting a stream survey for benthonic organisms with an Ekman dredge as a campler, as for example, a *Sphaeriid* survey, exploratory hauls should be made to determine if organisms are especially occupying but one type of bottom, i. e., sand or silt. From such preliminary sampling the collector can establish a fairly typical bottom to collect in from station to station.

8. Statements in the literature that indicate that the Sphaeriidae as a group are tolerant to water fouled by domestic sewage do not always appear to be valid. These clams should be identified to species as certain ones apparently may or may not tolerant intensive pollution from domestic sewage.

9. Under the conditions and period of time stated in this paper *Sphaerium solidulum* Prime was not tolerant of intensive pollution from domestic sewage. Thus, this clam proved to be a negative indicator organism.

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